MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

ETM4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(All sections / groups)

12 OCTOBER 2017
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of five (5) pages including this cover page with five (5) questions only.

2. Attempt all **FIVE (5)** questions. The distribution of the marks for each question is given.

3. Please write all your answers clearly in the answer booklet provided.

Question 1

a) (i) Plastic can be used to guide light. Why is plastic fibre not used in the long haul communication system? [2 marks]

(ii) When is plastic fibre useful? [3 marks]

b) (i) Describe the modified chemical vapour deposition (MCVD) process of manufacturing glass graded index optical fibre. [9 marks]

(ii) A silica tube has inner and outer radii of 3 mm and 4 mm respectively. What should be the thickness of the inner surface glass deposition if a fibre is to have a final core diameter of 50 μm and an outer cladding of 125 μm diameter using MCVD process? [6 marks]

Question 2

(a) Describe the necessary conditions for total internal reflection (TIR) to exist in an optical fibre. [4 marks]

(b) The number of modes in an optical fibre is $M = 2125$. The core refractive index, $n_1 = 1.480$ and the cladding refractive index, $n_2 = 1.465$. Find the following:

(i) Numerical aperture, NA. [3 marks]

(ii) Normalised frequency, V. [3 marks]

(iii) If the core diameter is 62.5 micron, find operating wavelength of the above fibre. [3 marks]

(c) (i) What is material dispersion? [4 marks]

(ii) An LED at 850nm has a spectral width of 45nm. What is the pulse spreading in ns/km due to material dispersion?
(Material dispersion at 850nm, $D(850\text{nm}) = -90$ ps/(nm.km) and at 1550nm, it is $D(1550\text{nm}) = 20$ ps / (nm.km) [3 marks]

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Question 3

(a) A double heterojunction InGaAsP LED has a peak wavelength of 1310nm. Its radiative recombination time is 25ns and its nonradiative recombination time is 90ns. The drive current is 35mA.

(i) Find the internal quantum efficiency, η . [4 marks]

(ii) Find the internal power level. [3 marks]

(iii) The refractive index of the light source material is $n = 3.5$. Find the power emitted from the device. [3 marks]

(b) A Si PIN photodetector has a depletion width $w = 20$ μm, an area, $A = 0.05$ mm^2, a dielectric constant $K_s = 11.7$, operating wavelength of 800 nm, 10 kΩ load resistor, and the absorption coefficient $\alpha_s = 10^3$ cm^{-1}.
(The electron speed is 8.4 x 10^6 cm/s and the hole speed is 4.4 x 10^6 cm/s.)

(i) Find the RC time constant. [4 marks]
(ii) Find the carrier drift time. [3 marks]
(iii) Which time is critical in limiting the response speed of this photodetector? [3 marks]

Question 4

Write a brief description for each of the following terms:

(a) Rayleigh Scattering [2 marks]

(b) Stimulated Raman Scattering (SRS) [4 marks]

(c) Stimulated Brillouin Scattering (SBS) [4 marks]

(d) Four Wave Mixing (FWM) [4 marks]

(e) Self Phase Moduleation (SPM) [4 marks]

(f) Group Velocity Dispersion (GVD) [2 marks]

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Question 5

A digital fibre optic link is operating at 622 Mb/s over 80km without amplifier is in operation. A single mode InGaAsP laser at 1550nm launches an average optical power of 3.0 dBm into the single mode fibre. The splice loss is 0.1dB for every km. The coupling loss at the receiver is 0.5dB. Excess noise penalties are 1.5dB.

(a) An APD has a sensitivity of -31dBm.
What is the minimum detectable optical power? [4 marks]

(b) The fibre has a loss of 0.25 dB/km. What is the total fibre loss over 80km? [3 marks]

(c) What is fibre splice loss and coupling loss? [5 marks]

(d) Set up an optical power budget for this link. [5 marks]

(e) Find the system margin. [3 marks]

End of Page

Appendix : Physical constants and formulae

Physical constants:

Vacuum permittivity: $\varepsilon_0 = \frac{10^{-9}}{36\pi} = 8.85418 \times 10^{-12}\ F/m$

Vacuum permeability: $\mu_0 = 4\pi \times 10^{-7} = 1.25663 \times 10^{-6}\ H/m$

Speed of light: $c = 2.998 \times 10^8$ m/s

Elementary charge: $q = 1.60218 \times 10^{-19}\ C$

Boltzmann constant: $k_B = 1.38066 \times 10^{-23}\ J/K$

Planck's constant: $h = 6.62617 \times 10^{-34}\ Js$

1 electron volt: $1eV = 1.60218 \times 10^{-19}\ J$

Vacuum intrinsic impedance: $\eta_0 = 120\pi[\Omega]$

Useful formulae:

1. $\text{NA} = \sqrt{n_1^2 - n_2^2}$

2. $M = \frac{V^2}{2}$

3. $\frac{P_{clad}}{P_{total}} = \frac{4}{3\sqrt{M}}$

4. $V = \frac{2\pi}{\lambda} a\ NA$

5. $\sigma_M = \sigma_\lambda L|D(\lambda)|$

6. $\Delta\lambda = \frac{\lambda^2}{2nL}$

7. $\frac{1}{\tau} = \frac{1}{\tau_R} + \frac{1}{\tau_{NR}}$

8. $C = \frac{\epsilon_o K_s A}{w}$

9. $P_{int} = \eta_{int} \frac{hcI}{q\lambda}$

10. $P_{emit} = \eta_{ext} P_{int} = \frac{P_{int}}{n(n+1)^2}$

End of Paper